1,157,711

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,157,711

Date of filing Complete Specification: 23 Jan., 1968.

Application Date: 24 Oct., 1966. No. 47667/66.

Complete Specification Published: 9 July, 1969.

Index at acceptance:—H5 H(2G1, 2G2X)

Int. Cl.:—H 05 b 5/02

COMPLETE SPECIFICATION

Improvements in or relating to Electrical Cooking apparatus and Utensils for use therewith

We, THE ELECTRICITY COUNCIL, a British Body Corporate, of 30 Millbank, London, S.W.1., MAURICE GORDON GIBBS, a British Subject, of 11 Orchard Lane, Childer Thornton, Wirral, Cheshire, and (DR) ARTHUR TREVOR CHURCHMAN, a British Subject, of St. Garrards, Pantasaph, Holywell, Flintshire, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

A domestic electric cooker makes use of an electrically heated element, typically a hot plate, on which a utensil such as a saucepan is placed. Heating of the suaucepan and the contents thereof is effected primarily by conduction but partly by radiation and commonly an appreciable part of the consumed electrical energy is wasted. For some purposes, for example for heating water, it is possible to use an immersion heater in a kettle so that the water is heated directly by conduction from the surface of the element and thereby less energy is wasted. However an immersion heater cannot be used for cooking food in saucepans.

It is known however to make use of inductive heating by means of a ferro-magnetic core with a winding energised by alternating current on the cooker, so that eddy currents are induced in an electrically conducting plate forming part of the cooking utensil, e.g. a saucepan.

According to this invention, electric cooking apparatus for heating the contents of a utensil such as a saucepan comprises a ferro-magnetic core formed of laminations or particles and carrying a winding or windings arranged for energisation with alternating current, the core having two or more upwardly facing poles and wherein there is provided a flexible sheet of a material which is neither ferro-magnetic nor electrically conductive extending across the top surface of the ferro-magnetic core to cover the poles to form a liquid tight seal. This sheet is in the form of flexible sheet of a material such as silicone rubber. The purpose of this seal is to isolate the core and winding from any material which may be split on the top surface of the cooking apparatus. This sheet of flexible material also acts as a sound deadening medium to reduce any noise due to mechanical vibration between the bottom of the utensil and the upper surface of the core.

This cooking apparatus is used in combination with a utensil, such as a saucepan, formed of non-magnetic material but having, embedded in the base or secured on the base or located within the utensil on the base thereof, a ferro-magnetic member surrounded by electrically conductive material, said ferro-magnetic member being of sufficient size to bridge the poles on the cooking apparatus.

With this construction, when the utensil is placed on the poles of the cooking apparatus, the alternating magnetic flux passes through the ferromagnetic member in the utensil, which member is typically a steel disc, and this magnetic flux induces a circulating current in the ferro-magnetic member if that member is electrically conductive and also in the electrically conductive material surrounding the member. This conductive material in effect forms a short-circuited turn of a transformer of which the primary winding is constituted by the winding on the core of the cooking apparatus; the utensil with its contents is heated by the induced current flowing in this conductive material and also flowing in the ferro-magnetic member if the latter is electrically conductive.

The cooking apparatus may be constructed for direct energisation from an alternating current supply mains at 50 or 60 cycles per second and, as will be explained later, it has been found possible to obtain an extremely high degree of efficiency in the utilisation of the electric power for the heating of the utensil and its contents.

For maximum efficiency, the ferro-magnetic

[Price 4s. 6d.]

member of the utensil should be shaped and positioned to ensure that the maximum flux is channelled transversely through the electrically conductive material with the minimum of leakage field in the air. For this reason, the ferro-magnetic member is preferably a flat plate of sufficient thickness such that it is not magnetically saturated and of a size just sufficient to bridge the poles of the cooking apparatus. The ferro-magnetic member should be close to these poles and preferably therefore is embedded in or forms part of the bottom of the utensil. It is desirable, but not essential, to have the electrically conductive material on both the underside and the upper side of the ferro-magnetic member as sell as surrounding its periphery. Conveniently therefore the utensil is made of a suitable conductive but non-magnetic material, such as aluminium, copper or austenitic stainless steel with a ferro-magnetic steel disc embedded, e.g. cast, in the base of the utensil.

The cooking apparatus however will also operate of a non-magnetic but electrically conductive utensil, such as an aluminium saucepan, is used but in this case the electrical efficiency, that is to say the ratio of the power induced in the utensil to the total power consumed by the cooking apparatus, is very much lower. To improve the efficiency of such a utensil or to effect cooking in a utensil which is not electrically conductive e.g. a glass or earthenware vessel, a disc of ferro-magnetic material, conveniently a suitable steel, surrounded by electrically conductive material may be placed in the bottom of the utensil.

Most cooking utensils are of circular form in plan and conveniently the core of the cooking apparatus is formed with a central pole surrounded by an annular pole, a winding for energising the core being arranged around the central pole. Such a core may conveniently be constructed of laminated material built up to form an assembly which has an annular groove in which the winding is located, this annular groove lying between the central pole and the annular outer pole. Instead of using a laminated core, it is possible to use a powder iron core, using for example ferrite material or using steel particles moulded in a binder such as an epoxy resin.

However other constructions may be employed for the core for the cookers depending on the requirements. The core assembly need not be circular. It may, for example be square or rectangular and it may have more than two poles. An electric cooker for domestic use would typically have three or more such cores for heating separate utensils and these cores may be of the same or different sizes.

The following is a description of a number of embodiments of the invention reference beind made to the accompanying drawings in which:—

Figure 1 is a vertical section through part of a cooking apparatus and part of a utensil for use therewith;

Figure 2 is a horizontal section along the line 2—2 of Figure 1;

Figures 3, 4 and 5 are vertical sections through further constructions of the cooking utensil and apparatus for heating the utensil;

Figure 6 is a horizontal section through a heater in another construction of cooking apparatus;

Figure 7 is a vertical section of Figure 6; and

Figure 8 is an explanatory diagram illustrating the path of the magnetic flux.

Referring to Figure 1 the cooking apparatus has a laminated iron core 10. The laminations have insulation between them as in a transformer and the laminated structure is machined to form an annular channel 11 within which is located a winding 12 of aluminium or copper wire. The core thus has a central pole 13 together with an annular outer pole 14. The top surface of these poles is covered with a flexible seal 15 formed of a sheet of silicone rubber. Part of a utensil 16 is shown in the drawing, this utensil being formed of an electrically conductive but nonmagnetic material such as aluminium, copper or austenitic stainless steel. Cast into the bottom of the suacepan and completely surrounded by the non-magnetic material is a steel disc 17 formed of a ferro-magnetic steel. The disc is keyed to the material of the pan by means of a number of holes in the steel disc through which the non-magnetic material forming the body of the suacepan flows during the casting process.

When the winding 12 is energised with alternating current from a mains supply at a frequency of 50 or 60 cycles per second, the iron core 11 is energised and an alternating magnetic field is produced between the poles 13, 14 of the core. The steel disc 17 in the cooking utensil forms part of the magnetic circuit and, as shown in Figure 7, causes the flux to be channelled through this core and hence to pass substantially through the non-magnetic but conductive base of the saucepan. Since the disc 17 is not laminated, the changing magnetic flux will induce a circulating current in it thereby producing heat which is transferred to the saucepan by conduction. More particularly however the electrically conductive part of the saucepan, particularly under the steel disc 17, is subjected to a changing magnetic field and this material acts as a short circuited turn of a transformer; current is induced therein and hence heat is generated.

Part of the function of the disc 17 is to ensure that the flux between the inner and outer poles 13, 14 of the cooker unit passes substantially through the non-magnetic bottom of the saucepan instead of producing leakage flux in the air which flux would not be available for generating secondary current. Because

of this flux channeling and the resultant better utilisation of the magnetic field, the power factor of the induction heater is considerably improved compared with a construction in which no steel disc 17 is employed. This improvement in the power factor is related, however, inter alia to the thickness and electrical resistivity of the non-magnetic but electrically conducting material on the lower side of the disc 17. It will be appreciated that the cooking apparatus would operate with a non-magnetic but electrically conducting container without a steel disc, for example an aluminium saucepan, but not only is the power factor reduced compared with the utensil shown in Figure 1 but also the electrical efficiency of the system is very much lower. In a typical construction, a utensil such as shown in Figure 1 with a steel disc 17 might have a power factor of 0.7 or higher and an efficiency, that is the ratio of the power induced in the utensil to the total power consumed by the apparatus, of 92%. Without the steel disc the power factor might typically be 0.3 and the efficiency 50%.

Figure 3 illustrates a modification of the apparatus of Figure 1 and the same reference numerals are used to indicate corresponding features. In Figure 3 however the construction of the steel disc is different. The disc shown at 20 in Figure 3 has an annular flange 21 at the edge so that the surface of this flange 21 is level with the bottom surface of the container. This flange 21 has the same diameter as the outer pole 14 of the core 10. The non-magnetic material of the container extends over the upper side of the steel disc as shown at 22 and completely surrounds the periphery thereof. This material also extends across the under surface of the disc within the flange as shown at 23.

Figure 4 illustrates a modification of the construction of Figure 3 and the same reference numerals are used to indicate corresponding features. In the construction of Figure 4, the steel disc 20 has an annular flange 21 of the same diameter as the outer pole 14 of the core 10. The disc 20 is also provided with a central pole *50* which is the same diameter as the central pole 13 of the core 10. The non-magnetic material of the container extends over the upper side of the steel disc as shown at 22 and completely surrounds the periphery thereof. This material also fills the annular channel in the under surface of the disc as shown at 51.

Figure 5 illustrates how the core and winding assembly of the cooking apparatus shown in Figure 1 may be used with a conventional cooking utensil 30. If this utensil is formed of electrically conductive but non-magnetic material, such as aluminium or copper, a ferro-magnetic steel disc 31 having a protective outer cover 32, typically of plastics, is placed inside the utensil. This disc is of sufficient size to extend across the poles of the core 10 and acts in a similar manner to the steel disc 17 of Figure 1 to channel the flux so that current is induced in the base of the utensil. If the utensil is a non-conducting material, such as glass or earthenware, the steel disc 31 would be enveloped in aluminium or other suitable electrically conductive, low resistivity, non-magnetic material. If this utensil 30 is of a magnetic material such as steel, it may be so thin as to be magnetically saturated before sufficient power can be induced in it thereby giving a poor power factor and low efficiency. In this case, a steel disc 31 covered either with a non-conductive, non-magnetic material or with a conductive non-magnetic material, depending upon the power required and the thickness of the container bottom can be used.

It is not necessary to use a circular core structure and Figures 6 and 7 illustrate a core arrangement to provide a long rectangular heater in which there are three poles 40, 41, 42 surrounded respectively by windings 43, 44, 45. A flexible seal 46 of silicone rubber is used as before to cover the pole faces so as to isolate the winding and core structure from any material split on the top of the cooking apparatus and also to act as a sound deadening medium.

WHAT WE CLAIM IS:—

1. An electric cooking apparatus for heating the contents of a utensil, such as a saucepan, comprising a ferro-magnetic core formed of laminations or particles and carrying a winding or windings arranged for energisation with alternating current, the core having two or more upwardly facing poles and wherein there is provided a flexible sheet of material which is neither conductive nor ferromagnetic extending across the top surface of the ferro-magnetic core to cover the poles to form a liquid-tight seal.

2. An electric cooking apparatus as claimed in claim 1 in combination with a utensil formed of non-magnetic material but having, embedded in the base or secured on the base of the utensil or located within the utensil on the base thereof, a ferro-magnetic member surrounded by electrically conductive material, said ferro-magnetic member being of sufficient size to bridge the poles on the cooking apparatus.

3. The combination as claimed in claim 2 wherein said utensil is a saucepan.

4. The combination as claimed in either claim 2 or claim 3 wherein the ferro-magnetic member in or on or within said utensil is a flat plate.

5. The combination as claimed in claim 4 wherein the ferro-magnetic member is of sufficient thickness such that it is not magnetically saturated.

6. The combination as claimed in any of claims 2 to 5 wherein the ferro-magnetic member is embedded in the base of the utensil with the electrically conductive material on both the underside and the upper side of the

ferro-magnetic member as well as surrounding its periphery.

7. The combination as claimed in claim 6 wherein the utensil is made of a conductive but non-magnetic material with a ferro-magnetic steel disc embedded in the base of the utensil.

8. The combination as claimed in any of claims 2 to 5 wherein the utensil is made of a material which is not electrically conductive and wherein a disc of ferro-magnetic material surrounded by electrically conductive material is placed on the bottom of the utensil.

9. Cooking apparatus as claimed in claim 1 or the combination as claimed in any of claims 2 to 8 wherein the core of the cooking apparatus is formed with a central pole surrounded by an annular pole, a winding for energising the core being arranged around the central pole.

10. Cooking apparatus or the combination as claimed in claim 9 wherein the core is constructed of laminated material built up to form an assembly which has an annular groove in which the winding is located, this annular groove lying between the central pole and the annular outer pole.

11. Cooking apparatus or the combination as claimed in claim 9 wherein the core is a powder iron core.

12. Cooking apparatus as claimed in claim 1 or the combination as claimed in any of claims 2 to 8 wherein the core is square or rectangular.

13. Cooking apparatus as claimed in claim 1 or the combination as claimed in any of claims 2 to 8 wherein the core has more than two poles.

14. An electric cooker comprising cooking apparatus as claimed in claim 1 with two or more cores for heating separate utensils.

15. Electric cooking apparatus as claimed in any of the preceding claims wherein the flexible sheet is formed of silicone rubber.

16. Electric cooking apparatus substantially as hereinbefore described with reference to Figures 1 to 5 or Figure 6 and Figure 7 of the accompanying drawings.

17. The combination of electric cooking apparatus and a utensil substantially as hereinbefore described with reference to the accompanying drawings.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London, E.C.1.,
Chartered Patent Agents,
Agents for the Applicants.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1969.
Published by the Patent Office, 25 Southampton Buildings, London, W.C.2, from which copies may be obtained.

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2 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 1

Fig. 1.

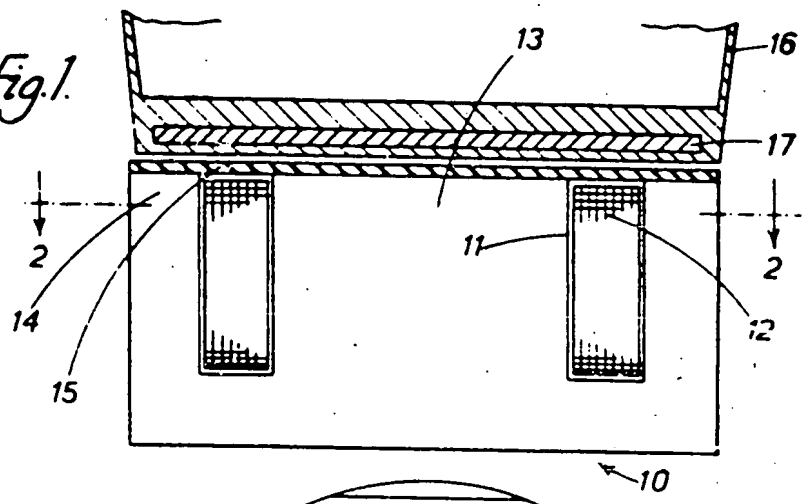


Fig. 2.

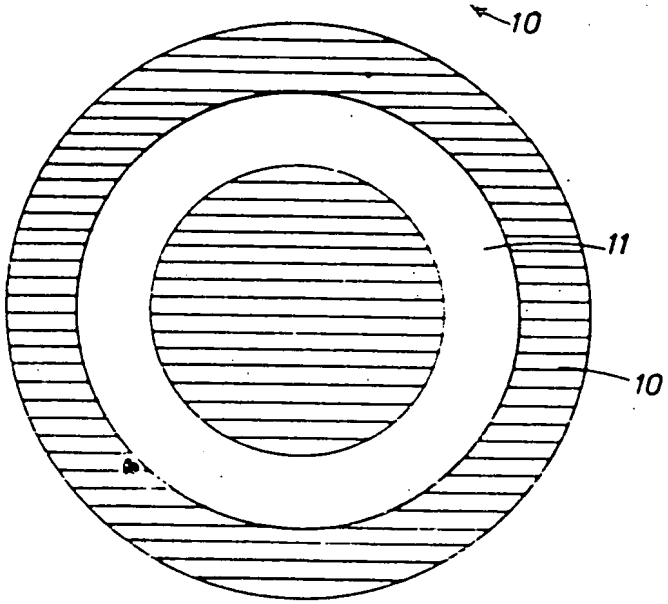
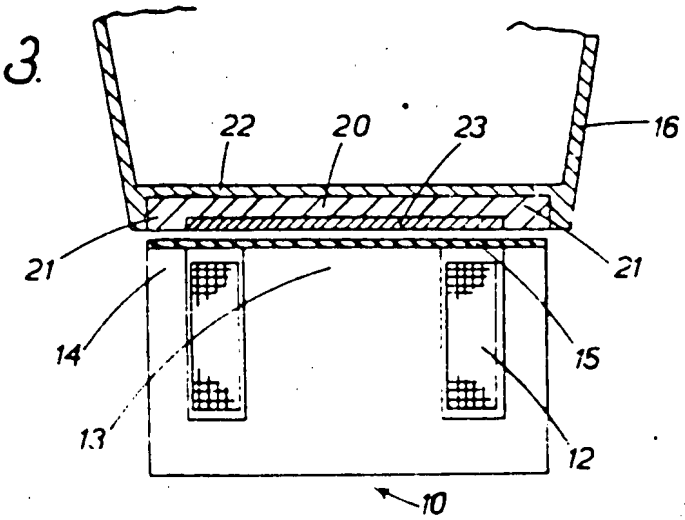


Fig. 3.



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Sheet 1

Fig. 1.

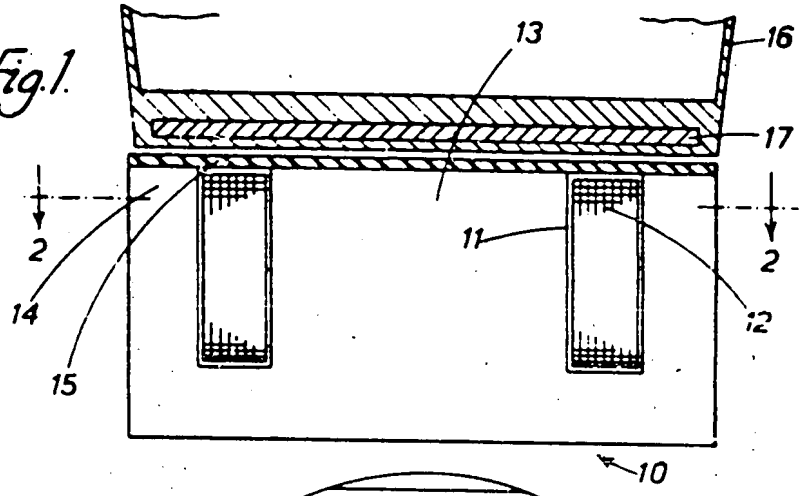


Fig. 2.

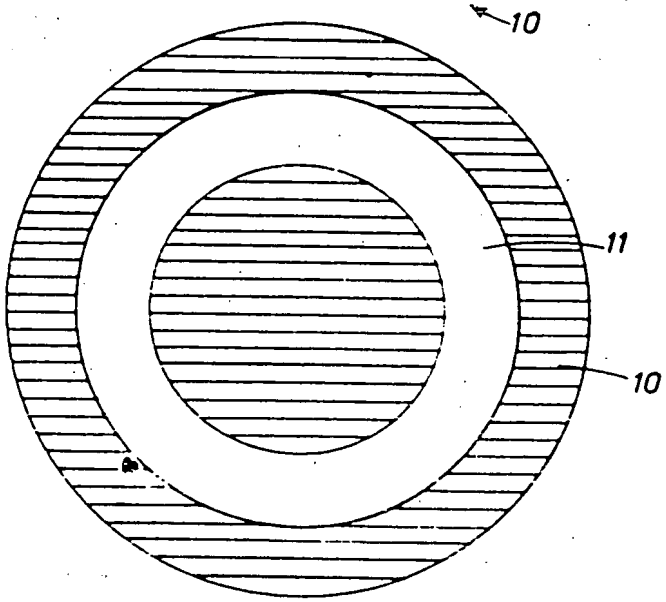
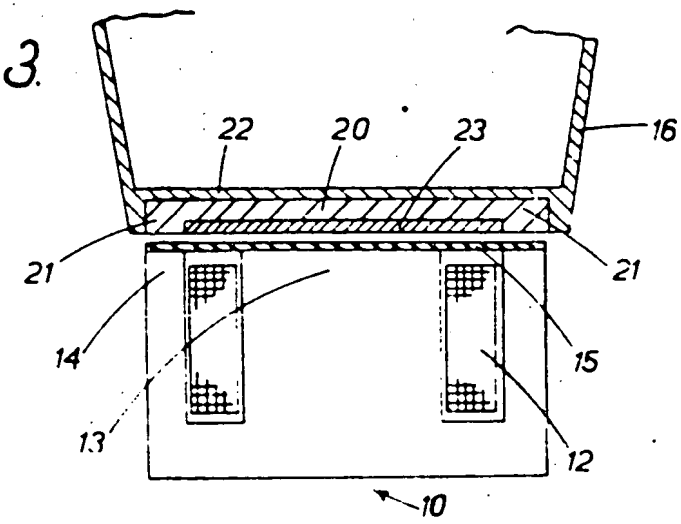


Fig. 3.



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Sheet 2

Fig. 4.

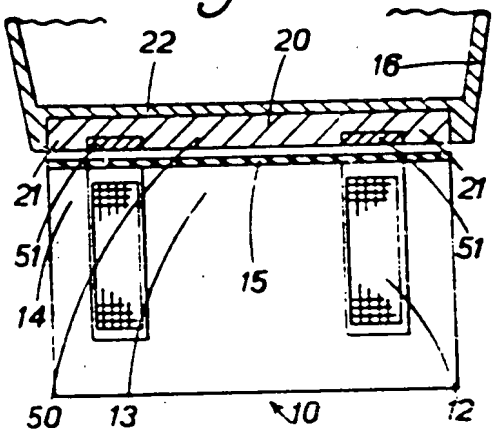

Fig. 5.

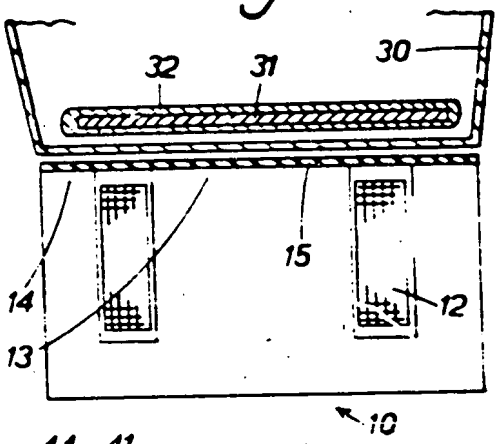

Fig. 6.

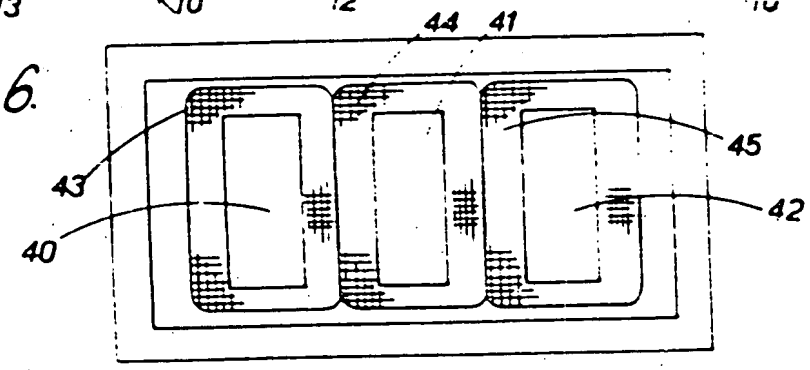

Fig. 7.

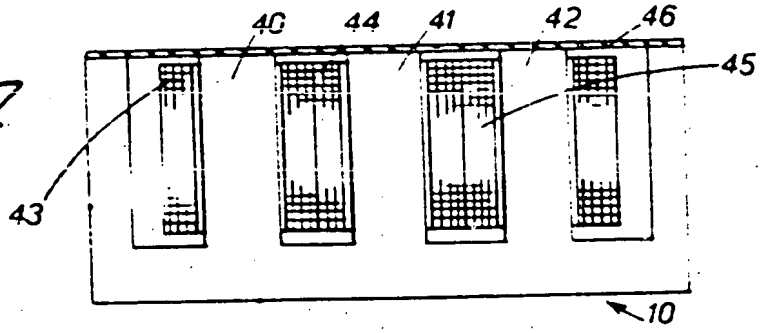

Fig. 8.